NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION WATER CONVEYANCE, FLEXIBLE MEMBRANE DITCH AND CANAL LINING

(feet)

CODE 428-B

DEFINITION

A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch or irrigation canal or lateral.

PURPOSES

This practice may be applied as part of a resource management system to support one or more of the following:

- Improve control and management of irrigation water.
- Prevent water logging of land due to excess seepage.
- Maintain water quality.
- Prevent erosion.
- Reduce water loss.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to buried membrane linings made of flexible materials, such as plastic, rubber, or asphalt. It includes design and construction criteria for the ditch section that affects the installation of linings as well for the lining itself.

Ditches and canals to be lined shall serve as an integral part of an irrigation water distribution or conveyance system designed to facilitate conservation use of soil and water resources on a farm or group of farms.

Water supplies and irrigation deliveries for areas served shall be sufficient to make irrigation practical for crops to be grown and irrigation water application methods to be used.

Lined ditches and canals shall either be located where they are not susceptible to damage from side drainage flooding or they shall be protected from such damage.

CRITERIA

General criteria applicable to all purposes

Capacity

A lined ditch or canal shall have enough capacity to meet its requirement as part of the planned irrigation water distribution system without danger of overtopping. Design capacity shall be based on the following, whichever is greater:

1. Capacity shall be adequate enough to deliver the water needed for irrigation, to meet design peak consumptive use of crops in the area served.
2. Capacity shall be sufficient to provide an adequate irrigation stream for all irrigation methods of irrigation planned for use in areas served.

Velocity

Velocities in canals or ditches lined with flexible membranes shall not exceed non-erosive velocity for the material used for protective cover or material through which the canal or ditch passes whichever is less. Local information on velocity limits for specific soils may be used if available.

If such information is not available, maximum design velocity shall not exceed 3 ft/s.

The velocity in ditch reaches from which water is to be delivered onto the field through turnouts, siphon tubes, or similar means shall be less than

supercritical and sufficiently low to permit operation of planned takeout structures or devices.

Canals and laterals lined with flexible membranes must be designed with enough capacity to carry required flows at velocities that will be developed under maximum probable retardance conditions.

For capacity design, Manning's value "n" shall be selected according to the material in which canals or laterals are constructed, alignment, hydraulic radius, and potential weed and moss hazard.

For checking designs to see that velocities do not exceed permissible values in erodible soils, a Manning's "n" no greater than 0.025 shall be used.

Freeboard

Required freeboard varies according to the size of the ditch or canal, velocity of the water, horizontal and vertical alignment, amount of storm or waste water that may be intercepted, and change in water surface elevation that may occur when any control structure is operating.

Minimum freeboard for any lined ditch or canal shall provide 3 inches of lining above the water surface. Minimum freeboard requirement is based on the assumption that the finished channel bottom elevation will vary no more than 0.1 ft from design elevations. If a construction deviation greater than 0.1 ft is permitted, minimum freeboard shall be increased.

Side slopes

Canals and ditches with buried membrane linings must be constructed with stable side slopes. Slope requirements vary according to the type of cover material, but side slopes shall not be steeper than 3:1.

Ditch or canal banks

Ditch and canal banks shall be constructed with earth to at least the top edge of the lining. In cut sections, other than in rock, a berm shall be constructed not less than 2 inches above the top of the lining. Banks and berms shall be wide enough to insure stability of fills and to prevent excessive deposition in cut sections.

For ditches being used to irrigate from, i.e. when using siphon tubes, minimum berm or bank width of 12 inches shall be provided at the top of the lining. All other canals and laterals shall have a minimum berm or bank width of 18 inches at top of lining.

If the bank or berm is to be used as a roadway, the minimum top width shall be adequate for the purpose. Minimum roadway width for straight sections is 12 feet.

Outside bank slopes and slopes above the berm elevation in cut sections must be flat enough to insure stability. Minimum slope is 2:1 except where vegetation will be maintained by mowing, the minimum shall be 3:1.

Protective cover

Membrane linings shall be protected by an earth or earth and gravel covering not less than 6 inches thick. Cover materials must extend at least 6 inches above the top edge of the lining. In areas subject to traffic by livestock, minimum thickness of the protective cover shall be 9 inches. Material covering the bottom shall be 3 inches thick and shall not be coarser than silty sand.

If the project necessitates installation without a protective soil cover, a variance may be allowed. Use of the variance (uncovered liners) will require the following as a minimum:

- A manufacturer's warranty for the intended purpose and against defects or environmental degradation that impacts minimum required performance
- Documentation of the location installed, material used, quantity of material and installation costs
- Annual reporting of Operation and Maintenance performed, problems encountered, corrective steps taken, and

associated costs for repairs. This information must be summarized for all jobs within each state and presented to NHQ in the form of a performance report every 3 years until the year 2000, at which time the variance allowance expires.

Membrane thickness

required membrane thickness depends on expected subgrade conditions, hydrostatic forces that will be acting on the membrane, and susceptibility of the lining to damage during or after installation. Minimum nominal thickness shall be in accordance with Table 1.

Anchoring membranes

All structures in the ditch shall be sealed off by the use of adhesive and pressure sensitive tape, or by other acceptable means.

Water surface elevations

All lined ditches and canals shall be designed so that water surface elevations at field takeout points are high enough to provide required flow onto field surfaces. If ditch checks or other control structures are to provide necessary head, backwater effect must be considered in computing freeboard requirements. Required elevation of water surface above field surfaces varies according to type of takeout structure or device used and amount of water to be delivered. A minimum head of 4 inches shall be provided.

Required water surface elevations vary with the type of takeout structure or device used and amounts of water to be delivered through each. Minimum head at gates, turnouts or siphon tubes shall be 4 inches. A minimum head of 6 inches is recommended. Where head is greater than 6 inches and on erosive soils, exit velocity from gates, turnouts or siphon tubes, may need devices to reduce energy.

Foundation Drainage

Foundation drainage, either natural or constructed, shall be sufficient to prevent hydrostatic (water) pressure under the lining, and subsequent lining displacement. External sources of foundation water include: springs, seeps, and up-slope runoff. Ditch seepage, either through the lining or from unlined ditch sections can also cause excess foundation water.

Related structures

Plans for ditch or canal lining installations shall provide for adequate inlets, outlets, turnouts, checks, crossings, and other related structures needed for successful conservation irrigation. These structures can be installed before, during, or after the lining placement. They must be constructed or installed in such a way as to not damage or impair the effectiveness of the lining.

Materials

All flexible membrane liners shall equal or exceed the physical requirements indicated for materials as set forth in Conservation Practice Specification, Materials, 428-B.

Table 1. Membrane type and thickness on various soils

Material	Asphalt	Plastic Sheeting	Non-reinforced Rubber	Reinforced Rubber
	mil	*mil*	*mil*	*mil*
Coarse Soils (SM-SP-SW)	225	10	30	20
Gravel (GC-GM-GP-GW)	---	12	30	30

CONSIDERATIONS

Water Quantity

1. Effects on the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential uses for irrigation water management.
4. Potential changes in growth and transpiration of vegetation located next to the conveyance because of the elimination

of leakage from the system.

Water Quality

1. Effects of installing the lining on the erosion of the earth conveyance and the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects of the practice on the movement of dissolved substances to ground water.
3. Effects of wetlands or water-related wildlife habitats.
4. Effects on the visual quality of water resources.

PLANS AND SPECIFICATIONS

Plans and specifications for installing non-reinforced concrete irrigation ditch and canal linings shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

An Operation and Maintenance plan must be prepared for use by the landowner or operator responsible for ditch and canal operation and maintenance. The plan should provide specific instructions for operating and maintaining the lining to insure it functions properly. Minimum requirements to be addressed in the Operation and Maintenance Plan are:

1. Prompt repair or replacement of damaged lining components is necessary. Remove foreign materials and vegetation that can interfere with proper lining operation.
2. Maintain berm and bank widths and maintain vigorous vegetative growth where applicable.
3. Remove debris and litter and any blockage that restricts capacity.
4. Control rodent to help prevent damage to lining

List items specific to the project on the "Operation and Maintenance Worksheet".

REFERENCES

USDA NRCS, National Engineering Field handbook for Conservation Practices, Chapter 3,6,15.

USDA NRCS, Standard Drawings Handbook Washington.

USDA NRCS, Engineering Design Standards Far West States.

NATURAL RESOURCES CONSERVATION SERVICE

GENERAL SPECIFICATIONS

IRRIGATION WATER CONVEYANCE

FLEXIBLE MEMBRANE DITCH AND CANAL LINING

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INSTALLATION

Preparing subgrades

Subgrades on which flexible membranes will be placed shall be raked to remove all large clods, roots, brush, sod, or rocks that might endanger the membrane. Rolling the subgrade is recommended to provide an extra measure of safety against punctures. In rocky areas, a cushion layer of fine soil shall be provided as a protection against irregularities that cannot be removed by rolling.

Placing membranes

Plastic and rubber membranes shall be carefully spread in a relaxed condition over the raked and smoothed subgrade. Rubber sheets may be pulled out smooth, but all liners shall be installed in a relaxed state. For polyethylene film, care shall be taken to insure that at least 5 percent slack is provided. Prefabricated asphalt membranes shall be pulled out so that they lay flat on the subgrade.

If the width or length of the lining specified requires placing sheets together, all joints shall be watertight, and the strength of the bonded seam in any direction shall not be less than 80 percent of breaking strength (ultimate tensile strength) of the membrane when the specimen is pulled in shear.

Anchoring membranes

Small anchor trenches about 10-in. (254-mm) wide and 12 in. (304 mm) deep shall be used to anchor the sides of the membrane. These trenches shall be located along the berm on both sides of the canal. They shall be a minimum of 4 in. (101 mm) back on the berm from the top of the side slope and at the elevation required to maintain the specified freeboard. The membrane shall conform to the trench shape and shall extend a minimum of 8-in. (203-mm) up the side opposite the canal. The trenches shall be carefully backfilled and compacted after the membrane is in place.

The upstream end of each section of plastic or rubber membrane shall be anchored in a trench dug across the canal. This trench shall be about 10 in. (254 mm) wide and 12 in. (304 mm) deep and shall connect with the two side anchor trenches. The upstream end of the membrane section shall lap down a minimum of 12 in. (304 mm) into this transverse trench. After the membrane is in place, the trench shall be carefully backfilled with selected compacted material. Prefabricated asphalt membranes shall be anchored at the upstream end of the lining section and at such intermediate points as are specified for individual jobs.

No anchors shall be required at the downstream end of membrane sections. The downstream end of the membrane shall be lapped a minimum of 3 ft (0.9 m) over the anchored upstream end of the next section. Placement of the protective cover material will secure the joint.

Placing protective cover

Material to be used as protective cover on membrane linings shall be free of large clods and sharp rocks and shall be carefully placed to the specified depth without damaging the membrane.

Construction operations

Construction operations shall be done in such a manner that erosion and air and water pollution are minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

MATERIALS

The flexible sheets or films to be used as buried membrane linings in irrigation ditches or canals shall be suitably constructed of high-quality ingredients and shall be certified by the manufacturer to be suitable for this intended use. Pigmented polyvinyl or polyethylene plastic, rubber, asphalt, or similar materials that are highly resistant to bacteriological deterioration shall be acceptable base materials for buried membrane linings.

The fabricated membranes shall be uniform throughout and shall be free from dirt, oil, foreign matter, pits, tears, holes, or other defects that can affect their serviceability. They shall be packaged so as to prevent damage from rough handling during shipment and so as to facilitate placement at the job site. Each package shall be marked with the name of the material, the manufacturer's name or symbol, the quantity contained therein, and the thickness or unit weight of the material.

Flexible membrane liners of the materials shown shall equal or exceed the physical requirements listed in table 1 (polyethylene and ethylene copolymer plastic film); table 2 (reinforced rubber sheeting); and table 3 (unreinforced rubber sheeting). Polyvinyl chloride plastic sheeting shall meet the requirements indicated in ASTM-D-3083, table 4, table 5 (unreinforced chlorisulfonated polyethylene), and table 6 (reinforced chlorisulfonated polyethylene).

Table 1. Requirements for polyethylene and ethylene copolymer plastic film.

Test description		Requirements		Test method
		Type I polyethylene	Type II copolymer	
Tensile strength				
Each direction, minimum average	*lb/in.*^{2}	1,800	2,000	ASTM-D-882, Method "A"
Ultimate elongation				
Each direction, minimum average	*pct*	500	500	ASTM-D-882, Method "A"
Impact resistance				
Minimum average	*g/mil*	45	65	ASTM-D-1709, Method "B"
Water vapor permeability	*perm-mil*	0.7	1.5	ASTM-E-96
Tear resistance (Elmendorf)				
Each direction, minimum	*g/mil*	80	80	ASTM-D-1922
Soil burial				
Tensile retained, each direction, minimum	*pct*	95	95	ASTM-D-3083
Elongation retained, each direction, minimum	*pct*	80	80	
Luminous transmittance, maximum	*pct*	1.0	1.0	National Bureau of Standards Publication PS-17

Table 2. Requirements for reinforced rubber sheeting

Test description		Requirements		Test method
		As much as 20 mils thick	20 mils thick and greater	
Breaking strength, minimum				
Warp direction	*lb/in.*	75	100	ASTM-D-751
Fill direction	*lb/in.*	75	100	ASTM-D-751
Ultimate elongation, maximum				
Warp direction	pct	30	30	ASTM-D-751
Fill direction	pct	30	30	ASTM-D-751
Ozone resistance, procedure "B"				
50 pphm, 100 ^{o}F	*days*	7	7	ASTM-D-1149 and ASTM-D-518
Hydrostatic strength retained after				
ozone exposure, 7 days (Mullen)	*pct*	100	100	Federal Specification CCC 191 b, Method 5512
Heat aging, 7 days at 212 ^{o}F				
Tensile strength retained	*pct*	90	90	ASTM-D-573
Elongation retained	*pct*	90	90	ASTM-D-573
Tear resistance, minimum, warp or				
fill direction	*lb*	8	8	ASTM-D-751 (tongue)
Hydrostatic burst (Mullen), minimum	*lb/in.*^{2}	100	175	ASTM-D-751
Dimensional stability, 7 days at 212 ^{o}F,				
change in length or width	*pct*	± 1.0	± 1.0	([1])
Low temperature flexibility (optional)				
No cracking or flaking		- 40 ^{o}F	- 40 ^{o}F	Federal Specification CCC 191 b, Method 5874
Commercial field splice strength				
Shear force, minimum tensile	*pct*	75	75	Commercial field splice 1-inch wide strip, pulled in shear at 10 in./min, after 7 days cure room temperature

[1]A 1-ft2 sample, 10 in. bench marks in warp and fill direction, placed on aluminum or stainless plate in changing air over.

Table 3. Requirements for unreinforced rubber sheeting

Test description		Requirements		Test method
		Type A	Type B	
Tensile strength, minimum	*lb/in.*^{2}	1,200	1,200	ASTM-D-412
Modulus at 300% elongation, minimum	*lb/in.*^{2}	600	600	ASTM-D-412
Ultimate elongation, minimum	*pct*	300	300	ASTM-D-412
Shore "A" hardness		60 ± 10	60 ± 10	ASTM-D-2240
Ozone resistance, procedure A				ASTM-D-1149
No cracks, 50 pphm at 100 °F, 20% elongation	*days*	7	—	ASTM-D-518
No cracks, 100 pphm at 100 °F, 50% elongation	*days*	—	7	ASTM-D-518
Heat aging, 7 days at 212 °F				ASTM-D-573
Tensile strength retained	*pct*	75	75	
Elongation retained	*pct*	75	75	
Water vapor permeability at 80 °F	*perm mil*	0.002	0.05	ASTM-E-96 (procedure BW)
Tear resistance, minimum	*lb/in.*^{2}	150	150	ASTM-D-624 Die "B"
Dimensional stability, 7 days at 212 °F, change in length or width	*pct*	± 0.5	± 0.5	
Commercial field splice strength shear force, minimum tensile	*pct*	60	60	Commercial field splice, 1-inch-wide strip pulled in shear at 10 in./min, after a 7-day cure at room temperature.

NOTE: Type A sheeting is recommended for general-purpose outdoor use. Type B sheeting is suggested if an extreme outdoor environment makes a highly wearable lining necessary.

Table 4. Requirements of polyvinyl chloride plastic sheeting

Test description		Requirements	Test method
Tensile strength, each direction, minimum average	*lb/in.*^{2}	2,000	ASTM-D-882
Elongation at break, minimum	*pct*	250	ASTM-D-882, Method A
Volatile loss, maximum	*pct*	0.7	ASTM-D-1203, Method A
Water extraction, maximum weight loss	*pct*	0.5	ASTM-D-1239
Tear resistance, each direction, minimum	*g/mil*	160	ASTM-D-1922
Resistance to soil burial (percent change max. in original value)			(120-day soil burial)
Breaking factor	*pct*	-5	
Elongation at break	*pct*	-20	
Modulus at 100% elongation	*pct*	± 10	
Bonded seam strength, percent breaking factor	*pct*	80	ASTM-D-3083 Para. 9.3 (1-inch width)

Table 5. Unreinforced chlorisulfonated polyethylene

Test description		Requirements	Test method
Tensile strength, minimum psi	*pct*	1,000	ASTM-D-412
Ultimate elongation, minimum	*pct*	250	ASTM-D-412
Ozone resistance, 50 pphm, 20% strain, 100 °F, 8,000 hrs	*pct*	± 0	ASTM-D-1149
Heat aging, 14 days at 212 °F			
Tensile strength, minimum psi	*pct*	1,000	
Elongation at break	*pct*	150	
Tear resistance, minimum	*lb/in*	250	ASTM-D-624 Die B
Commercial field splice			ASTM-D-882, Method A
Strength, shear force, minimum tensile	*pct*	60	(7 days cure)
Weight change after 7 days at 70 °C in water, maximum	*pct*	5	ASTM-D-471

Table 6. Reinforced chlorisulfonated polyethylene

Test description		Minimum requirements 30 mil thick and greater	Test method
Breaking strength, minimum			ASTM-D-751
Rubber	*lb/in*	100	
Fabric	*lb/in*	75	
Ultimate elongation, maximum			
Rubber	*pct*	150	
Fabric	*pct*	20	
Ozone resistance, 50 pphm, 20% strain at 100 ^{o}F, 8,000 hrs	*pct*	$\pm$ 0	ASTM-D-1149
Hydrostatic strength after ozone exposure, 7 days (Mullen), % retained	*pct*	100	Fed. Spec. CCC 191b Method 5512, ASTM-D-518
Heat aging, 14 days at 212 ^{o}F of original			
Tensile strength	*pct*	90	
Elongation % retained of original	*pct*	90	
Tear resistance, lbs minimum			ASTM-D-751
Warp or fill direction	*pct*	10	(tongue)
Puncture resistance, lbs minimum	*pct*	120	FTMS-101B, Method 2031
Commercial field splice			
Strength—shear force, % of minimum break	*pct*	75	ASTM-D-882, 7 days cure